

Renewable Energies for Remote Areas and Islands (REMOTE)

IEA-RETD

Microgrids Symposium, Santiago, Chile

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Trama TecnoAmbiental | Meister Consultants Group | HOMER Energy

Study:

▪ Theme	Integrating RETs in REMOTE areas: Transitioning to High-Penetrations of Renewable Energy
▪ Objectives	<ul style="list-style-type: none"> • To provide perspective on how to make remote areas and islands largely independent from fossil fuel imports or costly transmission infrastructure • To provide inspiration and concrete examples of how to accelerate renewable energy deployment in remote areas.
▪ PSG	RETD: Canada (Chair), Denmark, Ireland, Norway, UK Others: IRENA IITC, IEA-Hydrogen Implementing Agreement
▪ Implementing Body	Meister Consultants Group (US) with Homer Energy (US), Trama TecnoAmbiental (SP), and E3 Analytics (CAN)
▪ Planning	July 2011 – March 2012. Free and available at: http://iea-rettd.org/archives/publications/remote

Authors:



Agenda

- Background IEA RETD
- REMOTE – Study Brief
- Background – Price Trends
- Categories of Remote Areas
- Lessons learned – technical integration and case study example
- Financing – Challenges and New business models
- Conclusions

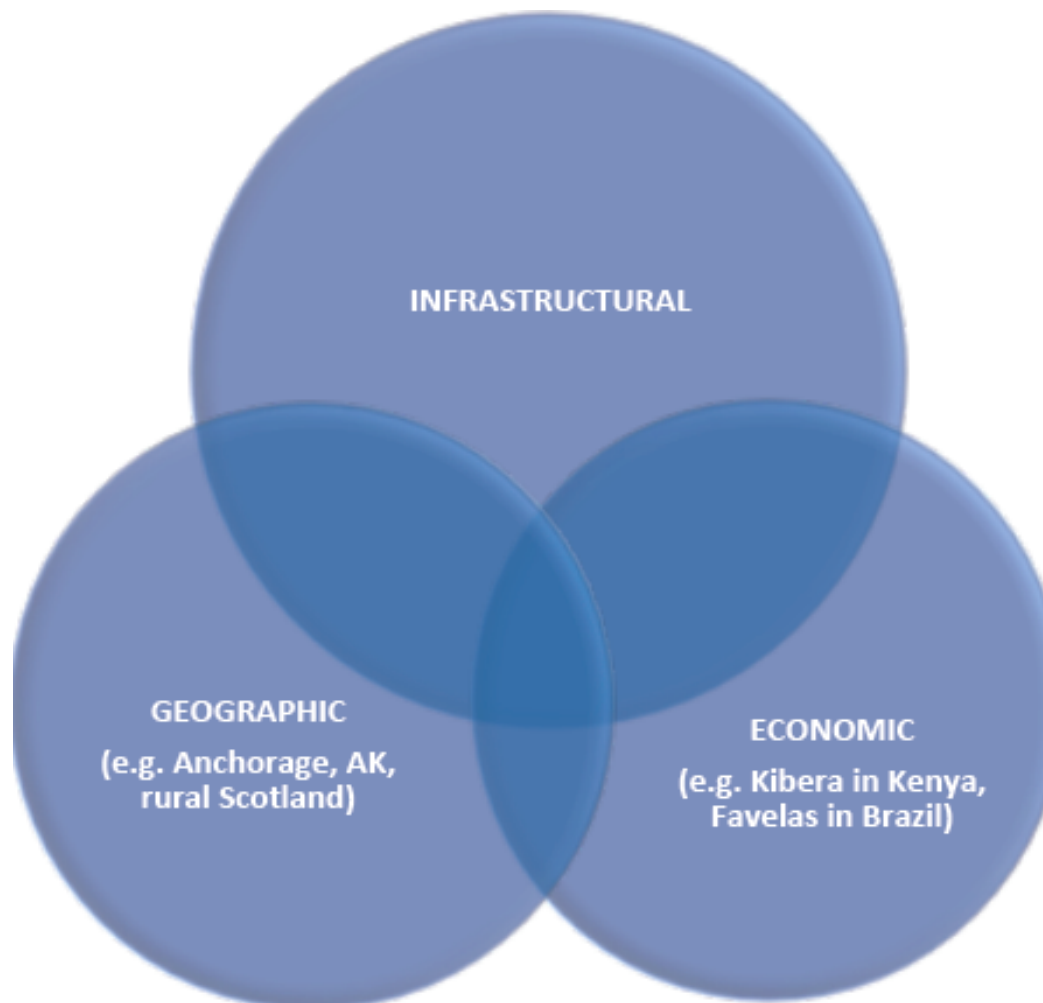
The mission of RETD is to accelerate the large-scale deployment of renewable energies

RETD stands for “Renewable Energy Technology Deployment”.

RETD is a policy-focused, technology cross-cutting platform that brings together the experience and best practices of some of the world’s leading countries in renewable energy with the expertise of renowned consulting firms and academia.

- Created in 2005, RETD is an Implementing Agreement that functions under the legal framework of the International Energy Agency.
- Currently 9 countries are members of the RETD: Canada, Denmark, France, Germany, Ireland, Japan, the Netherlands, Norway and the United Kingdom.
- RETD commissions annually 5-7 studies. The reports and handbooks are publicly and freely available on the RETD’s website at www.iea-retd.org.
- In addition, RETD organizes at least two workshops per year and presents at national and international events.

Different Dimensions of Remoteness:



Technical Considerations - Electricity

Technological Option	Advantages	Shortcomings
Micro grid fed by RE/ Hybrid power plant (small systems)	<ul style="list-style-type: none"> • Improved quality (surge power, load shedding, etc) • Lower investment for compact communities • Efficient maintenance • With genset backup: Power supply also during unfavourable weather conditions • Lower LCOE 	<ul style="list-style-type: none"> • Higher technological and organizational complexity • If there is a plant failure, everybody is cut off • Social rules required to distribute energy availability • Local management required • Need for storage systems
Hybrid integration of RETs (large systems)	<ul style="list-style-type: none"> • Distributed generation (generation is made in the consumption point) • Lower LCOE 	<ul style="list-style-type: none"> • Need to ensure grid stability due to intermittency of some RES • High penetration of RETs is a bigger challenge
Fossil-fuel generation	<ul style="list-style-type: none"> • Low initial investment costs • Status quo is not altered 	<ul style="list-style-type: none"> • High O&M and maintenance costs • High uncertainty in fossil fuel volatile prices • GHG emissions • Logistics risks when transporting diesel

Technical Considerations – Transportation and Heating

Considerations	Transportation	Heating
Alternatives	<ul style="list-style-type: none">• Biofuels (can be limitedly available in remote areas, assess availability and trade-offs if importing, food vs. fuel)• Efficiency and conservation• Switch to electric vehicles• Hydrogen	<ul style="list-style-type: none">• Biomass thermal• Solar thermal• Geothermal energy• Efficiency measures, passive design and integration• Electricity → heat

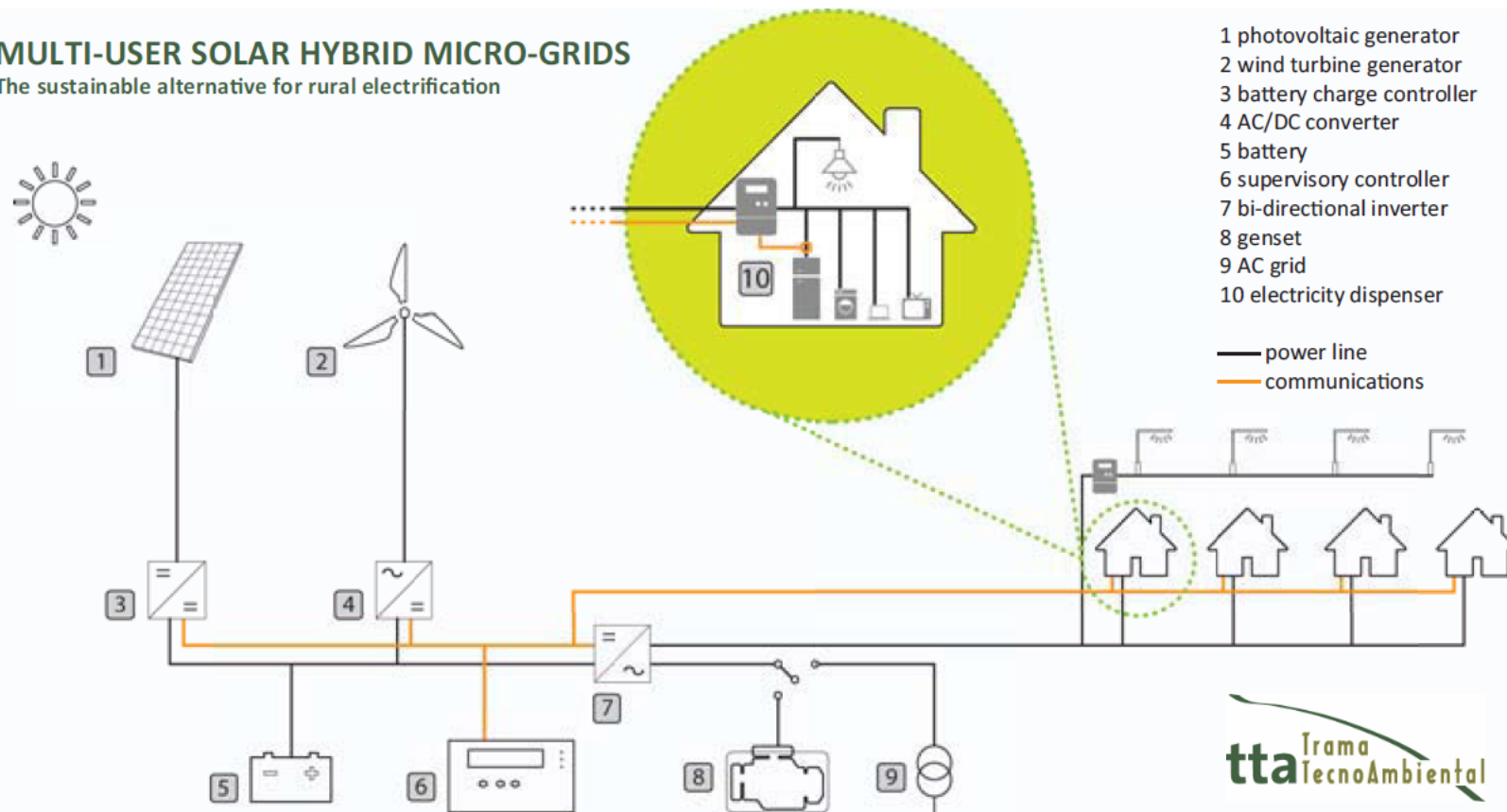


Electric vehicle developed in the Canary Islands. Courtesy of Gonzalo Piernavieja, Instituto Tecnológico de las Canarias

Technical Solutions are Available!

MULTI-USER SOLAR HYBRID MICRO-GRIDS

The sustainable alternative for rural electrification



Source: TTA

Technical Solutions are Available!

ELECTRICITY DISPENSER/METER FOR OFF-GRID MICROGRIDS

Built in main circuit breaker:

- *Energy Daily Allowance management*
- *Maximum current overload protection*

Auxiliary smart switch for:

- *load shifting*

Smart card for:

- *Tariff management*
- *Energy Allowance transfer*
- Limitation of energy to the contracted **energy daily allowance** with virtual storage
- The user pays a fixed monthly fee
- Flexibility to defer consumption and to consume at different dispensers



Electricity dispenser/meter for microgrids

Source: TTA

The study describes specific conditions and lessons learned for **six categories of remote areas**

	Case studies	Load demand, other considerations
1. Areas with long winters	<ul style="list-style-type: none"> Kodiak Island, Alaska Ramea, NFLD 	<ul style="list-style-type: none"> High heating loads Limited industrial activity, potentially subsistence activities and natural resources exploitation
2. Areas with temperate climates	<ul style="list-style-type: none"> Isle of Eigg, Scotland Faroe Islands, DK 	<ul style="list-style-type: none"> Not prone to environmental extremes Relatively high heat loads Often connected to central electricity infrastructure
3. Small areas with warm climates	<ul style="list-style-type: none"> Floreana, Galapagos Coral Bay, Australia 	<ul style="list-style-type: none"> High seasonal cooling needs for tourism Limited industrial activities
4. Large areas with warm climates	<ul style="list-style-type: none"> Bonaire, Caribbean El Hierro, Canaries Miyakojima, Japan Reunion, France 	<ul style="list-style-type: none"> Primarily residential and commercial (tourism) needs May have bulk access to fuels
5. Research stations	<ul style="list-style-type: none"> Ross Base, Antarctica 	<ul style="list-style-type: none"> Intermittent fuel deliveries Intermittent human occupation
6. Areas in developing countries	<ul style="list-style-type: none"> Akkan, Morocco 	<ul style="list-style-type: none"> Primarily residential with large growth potential Dependency on batteries, kerosene, wood and candles for primary energy needs

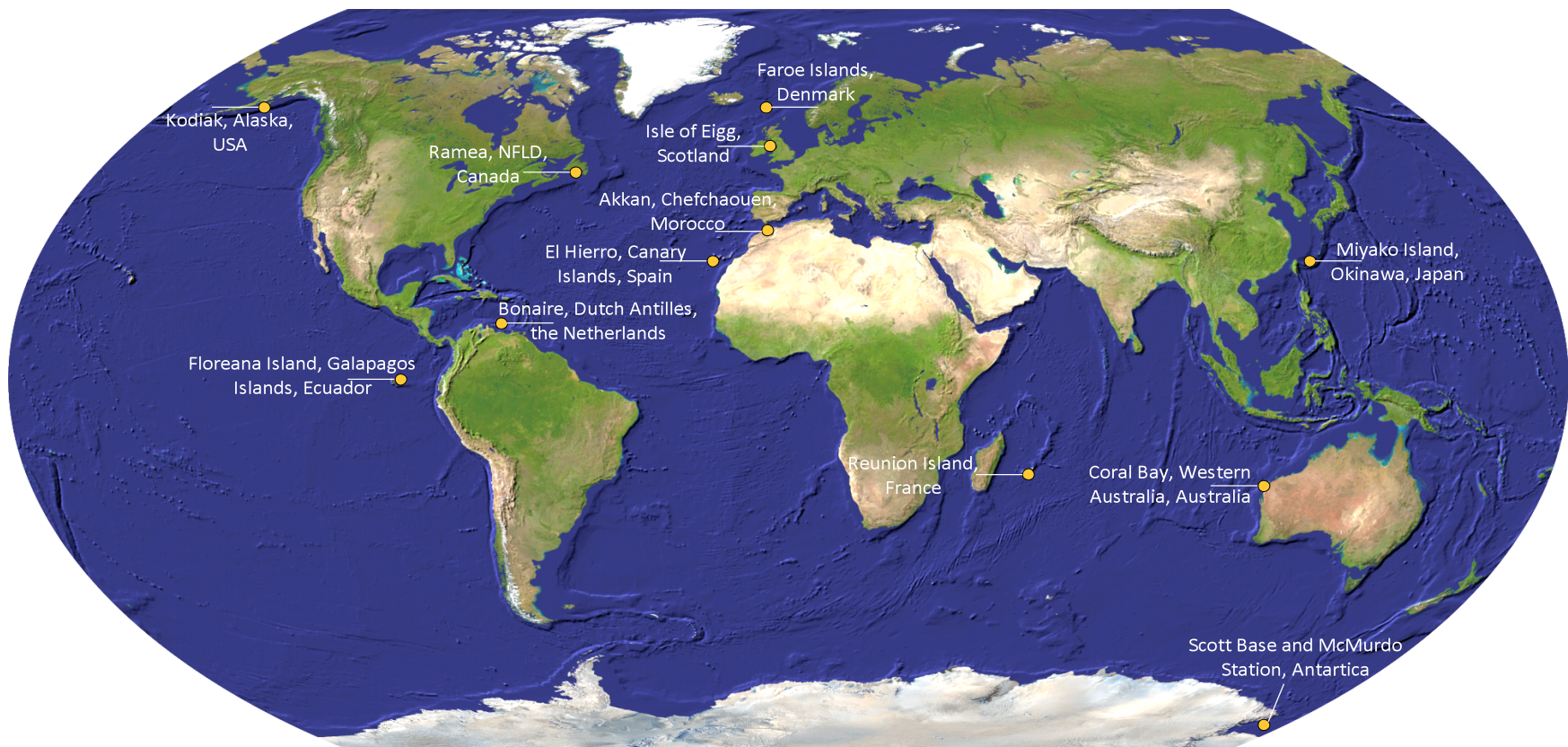
Categories Specific Considerations

Key Considerations:

		Cold	Temperate	Small Warm	Large Warm	Research stations	Developing countries
Energy Needs	Heating	★★★	★★	⊘	⊘	①	①
	Cooling	★	★★	★★	★★★★	①	①
	Electricity	★★★	★★★	★★★	★★★★	★★★	★★
	Internal Transport	★★★	★★★	★★	★★★★	★	★
Resources Availability	Solar	★	★★	★★★★	★★★★	①	①
	Wind	①	①	①	①	①	①
	Hydro	①	①	①	①	①	①
	Geothermal	①	①	①	①	①	①
	Biomass	★	★	★	★★	①	①
Access Challenge (external transport)		★★★	★★	★★	★	★★★	★★
Climate	Cold	★★★	★★	⊘	⊘	①	①
	Hot	★	★★	★★★★	★★★★	①	①
Demand Type	Residential	★★★	★★★★	★★★★	★★★★	★★★	★★★★
	Commercial	★	★★	★★	★★★★	⊘	★
	Industrial	①	★	★	★★★★	⊘	★
	Tourism	★	★★	★★★★	★★★★	⊘	★
Governance infrastructure		★	★★	★	★★★★	★	★
Energy poverty		★★	★	★★	★	⊘	★★★★
RET Electricity Penetration Rate feasible in the short-medium term		★★	★★	★★★★	★★	★★★	①
RET Heat Penetration Rate feasible in the short-medium term		★	★	★★	★★	①	①
RET Transport Penetration Rate feasible in the short-medium term		★	★	★	★	★	★

Legend	High	Medium	Low	Not Applicable	Site Specific
	★★★	★★	★	⊘	①

For each category, representative case studies were developed



Kodiak, Alaska, USA – Remote areas with long winters

	KODIAK ISLAND LESSONS LEARNED WIND/DIESEL HYBRID SYSTEM
TECHNICAL	<ul style="list-style-type: none"> For mid-size systems, a renewable transition plan should begin with low-penetration before proceeding to a high-penetration system.
SOCIO-ECONOMIC	<ul style="list-style-type: none"> Using renewables to offset diesel production can reduce electricity rates and provide long-term electricity price stability. On Kodiak, the wind electricity is estimated to cost US\$0.12/kWh (€0.08/kWh) while the diesel power cost estimate is US\$0.2538/kWh (€0.19/kWh) and rising.
INSTITUTIONAL	<ul style="list-style-type: none"> Including a training period in the first years of a projects operation can build capacity in the local utility. GE was contracted to provide the first 2 years of maintenance while training the KEA staff. This strategy enables the local operators to learn from the foreign experts.
FINANCIAL	<ul style="list-style-type: none"> Government subsidies may be necessary to help smaller utilities deal with the large upfront capital costs inherent in most renewable energy projects.
ENVIRONMENTAL	<ul style="list-style-type: none"> Winter weather conditions limited access to the project. The project had to be planned around a specific window when the weather was appropriate for installation.

CHARACTERISTICS	
Population	12,000
Project Description	This Pillar Mountain Wind Project installed three 1.5MW wind turbines
Generation (2010)	7.7% wind 85.3% hydro 7.1% diesel
Project Costs	US\$21.4 million
Ownership	Kodiak Electric Association



Pillar Mountain Wind Farm. Source: Dake Schmidt

Faroe Islands, DK – Temperate Remote Area

	FAROE ISLANDS, LESSONS LEARNED SEVERAL TECHNOLOGIES FOR ELECTRICITY AND HEATING
TECHNICAL	<ul style="list-style-type: none"> For mid-size systems, a renewable transition plan should begin with low-penetration before proceeding to a high-penetration system.
SOCIO-ECONOMIC	<ul style="list-style-type: none"> Using renewables to offset diesel production can reduce electricity rates and provide long-term electricity price stability. On Kodiak, the wind electricity is estimated to cost US\$0.12/kWh (€0.08/kWh) while the diesel power cost estimate is US\$0.2538/kWh (€0.19/kWh) and rising.
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FINANCIAL	<ul style="list-style-type: none"> Government subsidies may be necessary to help smaller utilities deal with the large upfront capital costs inherent in most renewable energy projects.
ENVIRONMENTAL	<ul style="list-style-type: none"> Winter weather conditions limited access to the project. The project had to be planned around a specific window when the weather was appropriate for installation.

CHARACTERISTICS	
Population	49,000
Project Description	<ul style="list-style-type: none"> 2 wind farms (Neshagi and Vestmanna) Wind → heat project (Nólsoy Island) Solar thermal (KREC)
Generation (2010)	55% fuel oil and gasoil 40% hydro 5% wind
Project Costs	<ul style="list-style-type: none"> Neshagi and Vestmanna: n/a Nólsoy: €280,000 KREC: €770,000
Ownership	<ul style="list-style-type: none"> Neshagi: SEV Vestmanna: Sp/F Røkt Nólsoy: Community-owned KREC: Municipality-owned

Coral Bay, AUS – Small Warm Remote Area

	CORAL BAY LESSONS LEARNED WIND/DIESEL HYBRID
TECHNICAL	<ul style="list-style-type: none"> Diesel generators should be adapted to meet the needs of a remote hybrid system. Common local extreme weather should be considered in designs to protect the RET investment. Vernet turbines were selected because they are able to lay down flat during cyclone and other high-wind events.
SOCIO-ECONOMIC	<ul style="list-style-type: none"> Load demand may be limited by limiting the number of tourists at one time. Overnight visitors to the town are capped at 3,600. This limits the tourism industry, but also limits the burden on local infrastructure.
INSTITUTIONAL	<ul style="list-style-type: none"> A single owner/operator can more easily achieve high-renewable penetrations in a hybrid system than trying to integrate renewables owned by one party with diesel generators owned by another party. Institutional experience with hybrid systems is critical for achieving high-penetration renewable systems.
FINANCIAL	<ul style="list-style-type: none"> Federal grants for renewable energy or remote projects may encourage private or public organizations to invest in remote areas. This project would not have been cost-effective without numerous federal grants.

CHARACTERISTICS	
Population	140 (residents) + up to 3600 (daily tourists)
Project Description	7 x 320kW diesel generators 1 x 500 kVA flywheel 3 x 275 kW wind turbines
Generation	Average: 40-60% power provided by wind turbines Up to 90%
Project Costs	€5.3 million
Ownership	Verve Energy



Vernet wind turbine installed in Coral Bay

Source: Powercorp Operations P/L

El Hierro, Canary Islands, SP – Large Warm Remote Area

	EL HIERRO LESSONS LEARNED WIND/HYDRO/DIESEL HYBRID
TECHNICAL	<ul style="list-style-type: none"> Use of innovative storage systems can increase penetration of intermittent RET. Optimization of instant demand response (system control technologies) permit the coupling of demand with resource availability. Diesel use is limited to periods with no water nor wind
SOCIO-ECONOMIC	<ul style="list-style-type: none"> Inclusion of a R&D technological institution will increase dissemination of know-how. RET projects can bring benefits that, while not expressible explicitly in monetary terms, can have significant positive impacts on quality of life and should be considered of equal or even greater importance than economic benefits.
INSTITUTIONAL	<ul style="list-style-type: none"> Government support can be a pivotal support. The government facilitated a €35M non-reimbursable fund through IDAE attached to the Ministry of Industry, Commerce and Tourism.
FINANCIAL	<ul style="list-style-type: none"> The creation of public-private partnerships will increase security for private investors and attract further funds. The project will lower the operational deficit covered by government. Project is expected to have a TIR of 7.5% and a PBP of 11 years.
ENVIRONMENTAL	<ul style="list-style-type: none"> The recognition of biodiversity's value and cultural heritage will strengthen and even motivate projects. Some environmental compromise may be necessary to achieve improvements.

www.iea-retd.org

CHARACTERISTICS	
Population	10,960
Project Description	Current: 12.7 MW diesel genset Under construction: 11.32 MW hydro power plant 6MW water pump to fill reservoir 11.5MW wind
Generation	Expected to produce up to 77% from hydro and wind resources
Project Costs	€64 million
Ownership	Gorona del Viento S.A.



Erection of wind turbines in El Hierro

Source: Instituto Tecnológico de las Canarias

A Moroccan project illustrates successful implementation of RE in remote areas of developing countries

	AKKAN, MOROCCO – LESSONS LEARNED PV HYBRID MICROGRID PROJECT
TECHNICAL	<ul style="list-style-type: none"> The use of energy daily allowance meters helps to prevent major system failures System upgrades will be necessary as users increase their reliance on the electrical system and consumption grows. Well-designed user and operator interfaces improve overall system performance.
SOCIO-ECONOMIC	<ul style="list-style-type: none"> Using a local installer will build local capacity while ensuring proper maintenance and technician availability. Access satisfaction.
INSTITUTIONAL	<ul style="list-style-type: none"> Community sustained projects are feasible if implemented properly.
FINANCIAL	<ul style="list-style-type: none"> Cooperation projects should seek for long-term sustainable operation of systems. International and public funds still play an important role in remote areas of developing countries for providing access to electricity. The creation of an O&M fund for major longer-term investments can create challenges.

CHARACTERISTICS	
Population	35 households
Project Description	5.6 kWp of PV 72 kWh battery 8.2 kW back-up diesel
Generation	95% Solar
Project Financing	80% from AECID 20% Local community
Ownership	Local Association of Akkan and Municipality of Chefchaouen



Akkan PV communal house

Source: TTA

The lessons learned are presented in five (5) aspects:

- 1. Technical lessons learned**
- 2. Socio-economic lessons learned**
- 3. Institutional lessons learned**
- 4. Financial lessons learned**
- 5. Environmental lessons learned**

A careful planning is necessary to optimize power systems with integrated hybrid solutions

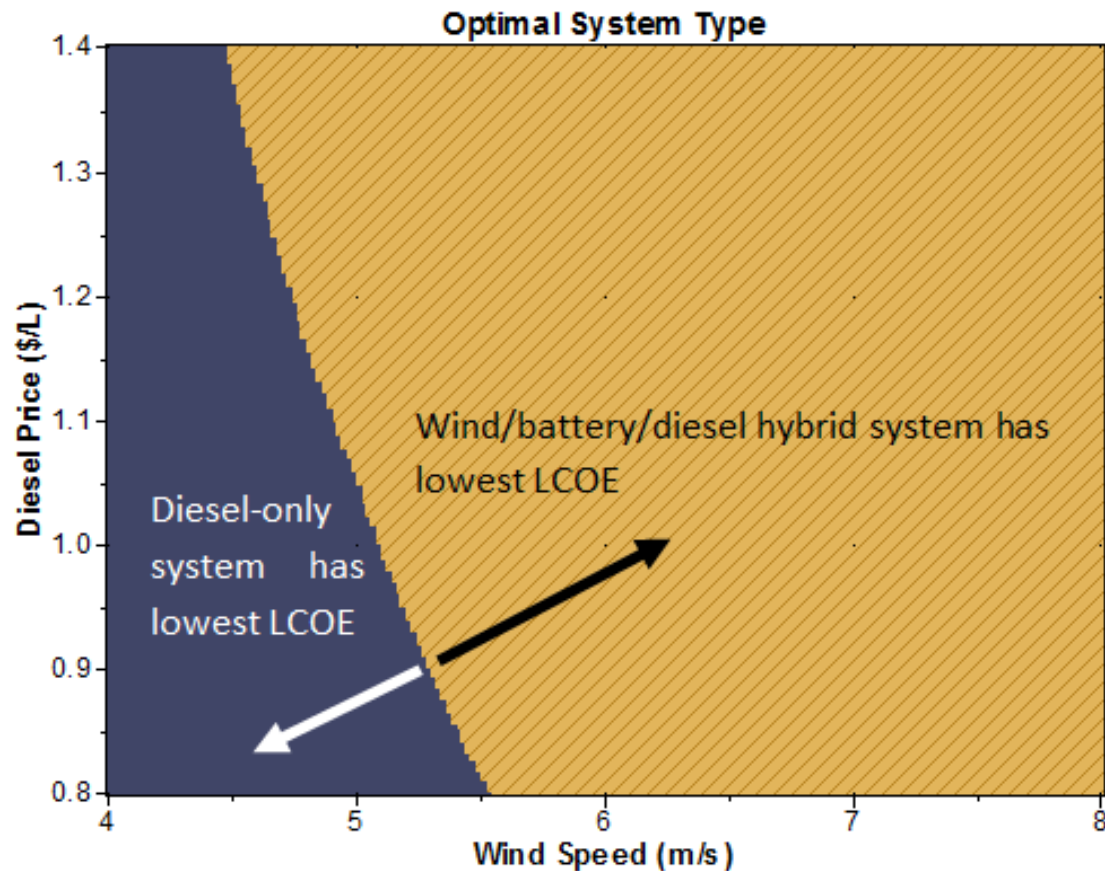


Figure 1: Optimal system type graph for providing electricity to a 150 person town near the Arctic circle

RET creates local benefits for remote areas

- RETs can support a range of economic activities
- RETs can create opportunities to improve the quality of life
- RETs can reduce the amount of subsidies required

Community involvement is important to energy development in remote areas

- Local expertise can be developed/utilized to support system O&M
- The community should be involved in the project
- RETs can be part of a broader sustainability portfolio
- The local private sector can be engaged to support RET development



www.iea-retd.org Mounting of PV system. Eigg Island, Scotland
Source: Meggie Fyffe at IEHT



Akkan, Morocco
Source: TTA

Examples of different ownership structures

Project	Ownership
Kodiak	
3 x 1.5 MW wind	Kodiak Electric Association (cooperative utility)
Ramea	
Phase 1 – 6 x 65 kW wind	Phase 1: Frontier Power Systems (developer) Phase 2: Nalcor (state-owned utility)
Phase 2 – 3 x 100 kW wind and 250 kW hydrogen system	
Faroe Islands	
2.13 MW wind	SEV (municipal utility)
1.98 kW wind	S/F Røkt (developer)
220 kW wind for electrical heat	NólsoyarOrkufelag (community company)
Solar thermal 200m ² , 10kW wind and hydrogen storage system	Community non-profit
Isle of Eigg	
100 kW Mini-grid	Eigg Electric Ltd (community-owned utility)
Floreana	
Phase 1: PV / diesel / battery hybrid	Junta Parroquial de Floreana (local authority)
Phase 2: 2 x 68 kW diesel gensets (fueled by jatroph	Elecgalapagos S.A. (utility)

Project	Ownership
Coral Bay	
3 MW wind/diesel/storage mini-grid	Verve Energy (state-owned generation company) Horizon Power (state-owned distribution company)
Bonaire	
Wind/diesel/storage hybrid	EcoPower Bonaire BV (private IPP)
El Hierro	
Wind/hydro/diesel hybrid, including a pumped hydro facility for storage	Gorona del Viento (public/private partnership IPP)
Miyakojima	
4 MW PV / battery smart grid	Okinawa Electricity Power Company (utility)
Reunion Island	
Large and small solar PV, solar thermal, wind, ocean, hydro, storage, algae, EVs	Varied ownership, some public, some hybrid, some private.
Scott Base and McMurdo Station	
3 x 330 kW wind turbines / flywheel	Antarctica New Zealand (a state-owned Crown corporation)
Akkan	
PV / diesel / storage microgrid	Joint ownership by municipality and community organization

The use of RETs provides an opportunity to demonstrate leadership in low-carbon technologies

- **RETs can achieve environmental goals of remote areas**
 - Benefit tourism
 - Help preserve pristine environments
 - Reduce reliance on fossil fuels (reducing incidence of spills, air and noise pollution, and GHG emissions)



Micro-hydro station in Eigg Island, Scotland

Source: Maggie Fyffe at IEHT

- Extreme weather conditions must be pondered when installing RETs
- RETs must also consider environmental impacts (e.g. impact on birds and bats of wind turbines) and adequate disposal and recycling strategies for RETs

The influence that cost of capital can have on remote area projects is high

- Financing costs play a critical role in determining the initial affordability, competitiveness, as well as the levelized costs of RE projects

The Role of Risk:

Forms of Risk	Questions
Timing Risk:	Will the project milestones be met, and built on time?
Force majeure risk:	Is the project exposed to major weather events, earthquakes, etc.?
Price Risk:	What price is the electricity sold for? What about inflation?
Performance Risk	Will the project perform as expected?
Counterparty Risk:	Will the off-taker be able to pay?
Operational Risk:	Is there adequate training for local technicians?
Political/Country Risk	How stable is the country politically and economically?
Currency Risk	How stable is the currency?

Risk Mitigation Vehicles:

Financial mechanism	Definition
Credit line	Provides a line of credit to local banks with which they can on-lend to remote communities
Guarantees	There are a broad range of different guarantees that could be applied in remote areas, including guarantees for project loans, guarantees that utilities will pay projects, etc. (Mostert et al., 2010)
Loan funds	Governments or utility funds established to make loans to entities at more favorable terms – such as lower interest rates or longer tenors – than they would otherwise be able to secure.
Loan buy-down programs	Governments provide funds to banks in order to reduce the interest rates at which banks will lend.

Innovative Business Models

- Performance contracting.
 - Financing energy upgrades, renovations, or rehabilitations based on the energy savings that the measures will generate.
 - Arrangements with third-party energy service companies (ESCOs)
 - But Project sizes might be too small or too geographically remote for private ESCOs to engage in.
- Fee-for-service models.
 - Electric utilities (private and public) or 3rd party providers maintain ownership of the RE system
 - They enter either a power purchase agreement or a lease arrangement with the system host.
 - Successful examples in the US and developing countries

Examples of Financing Structures

Project	Financing Structure
Kodiak	
3 x 1.5 MW wind	82% utility financed 18% grant financed
Faroe Islands	
2.13 MW wind 1.98 kW wind 220 kW wind for electrical heat Solar thermal 200m ² , 10kW wind and hydrogen storage system	Utility financed Privately financed 86% grant, 14% community equity 100% grant to date
Floreana	
Phase 1: PV / diesel / battery hybrid Phase 2: 2 x 68 kW diesel gensets (fueled by jatropa)	Phase 1: international donors, national / local government and users Phase 2: National government and international donors
Bonaire	
wind/diesel/storage hybrid	100% private project finance (80/20 debt:equity)
El Hierro	
El Hierro	10% private finance 35% public finance 55% grant

Selected stakeholder roles in remote areas:

Municipalities

Local energy training

Alternate power ownership models

Support EE & RET policies

Utilities

Train local technicians

Consult communities

Alternate power ownership models

Invest in renewables to lower operational costs

National government

Energy subsidy reform

Facilitate public-private partnerships

Detailed energy planning

Specialized incentives, financing and R&D

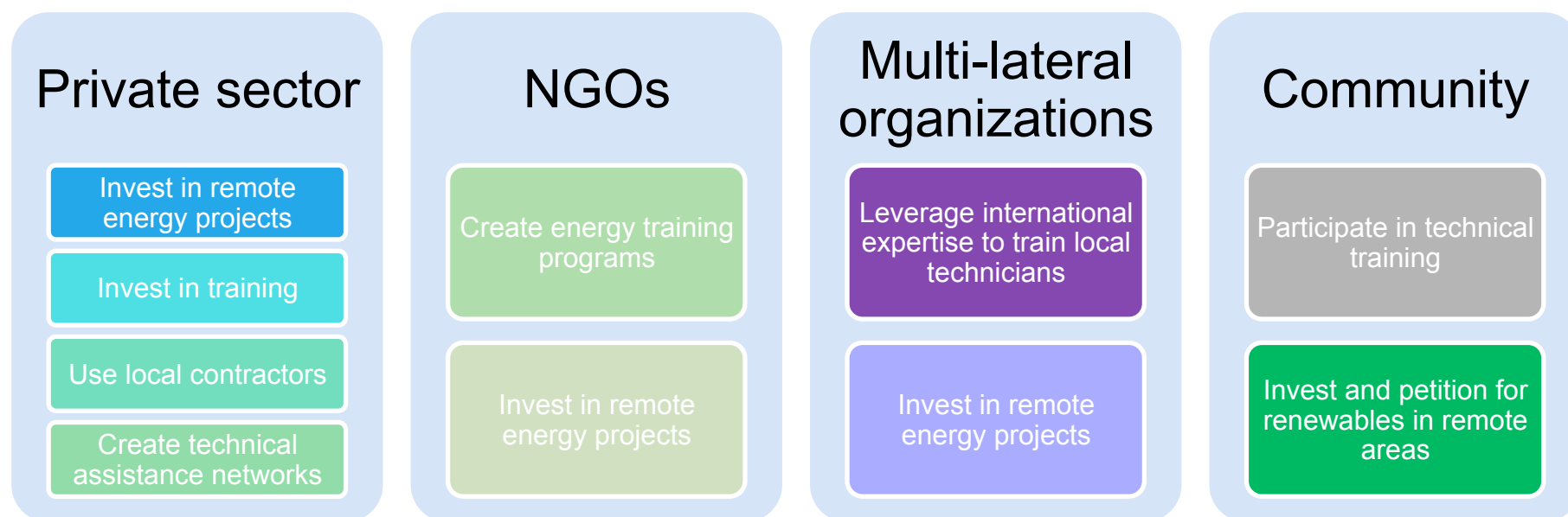
Academia

Create energy curricula for remote areas

Remote energy research

Research relevant to larger grids

Selected stakeholder roles in remote areas:



Key Insights:

- 1. Remote areas can be ideal testing grounds for almost mature technologies or applications**
- 2. Generation technologies can complement each other and can be matched in different ways to energy demand**
- 3. Remote areas are at the forefront of the innovative use of storage and load management techniques**
- 4. Community engagement is an important component of success**
- 5. Public funds can be used to leverage private funds**
- 6. Targeted risk mitigation can substantially improve the attractiveness of remote area projects to investors and funders**
- 7. While many RETs are increasingly cost-competitive with diesel, the ability of remote areas to finance projects without some kind of public sector involvement may be limited.**
- 8. In certain areas, the continued subsidization of fossil energy sources represents one of the chief barriers to the wider adoption of RETs**

CONCLUSIONS

- Governments can support RE by **scaling back fossil fuel subsidies**
- **Cooperation between government, communities, businesses, utilities, and the private sector is vital** to the success and sustainability of remote area projects
- **A more aggressive and targeted focus on energy efficiency** in all areas of energy use is essential
- Remote regions can act as a powerful proving ground for innovative technologies, and demonstrate that **a fully operational renewable energy future is not only possible, but within reach.**



THANK YOU!

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For additional information on RETD

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